IS CLIFFORD'S RULE STILL VALID? AFFIRMATIVE EXAMPLES FROM AROUND THE WORLD.

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In 1966 Clifford published a paper in which he confirmed and re-formulated a concept first stated by W.Q. Kennedy in 1964 that the occurrence of diamondiferous kimberlites is restricted to those parts of the earth's crust which Kennedy called "rigid cratonic nucleii of respectable antiquity, ±2000 M.y.".

Clifford, following Kennedy, observed that **economically** diamondiferous kimberlites, regardless of their age of intrusion, occur only in areas underlain by basement older than 1600 M.y. which he thought represented Archaean cratonic terrain. His observation was mainly related to occurrences in the African continent, but it appeared to be valid to Siberia as well where since 1955 many economically diamondiferous kimberlites were discovered on the large Siberian Platform.

A certain amount of confusion exists about the interpretation of the term craton. It is often used in a strict time - stratigraphic sense and then it is synonymous with Archaean basement. Hence the question "are these kimberlites on or off craton?", enquires whether or not the kimberlites in question occur in areas underlain by basement rocks of Archaean age. This is considered to have economic consequences.

It is also used in a broader structural-lithological sense in which cratons represent rigid, relatively immobile and generally low grade metamorphic parts of the Earth's crust in contrast to surrounding belts of highly deformed and high grade metamorphic rocks i.e. mobile belts, which can be as young as Palaeozoic in age, although the rocks of the craton are generally understood to be always of Precambrian age.

In this broader sense cratons are coherent blocks in the Earth's crust of any Precambrian age which have become rigid in that they react to surrounding or abutting tectonic forces by faulting, tilting or warping instead of folding. This cratonic condition is attained some time after their latest thermal event when the crustal block has thickened and cooled down.

Thus most cratons sensu lato are composed of blocks of Archaean or Early Proterozoic rocks, welded and surrounded by Proterozoic mobile belts. The whole assemblage often carries a bewildering array of local stratigraphic or structural names so that it is confusing for a geologist, not familiar with the area, to understand the tectonic pattern.

In 1984 and again in 1991 the author proposed a simple classification of cratonic blocks into three major divisions, i.e. -

(i) Archon - in which the basement rocks are of Archaean age;
(ii) Proton - in which they are of Early to Middle Proterozoic age;
(iii) Tecton - in which they are of Late Proterozoic age.

The time boundaries between these divisions have been selected as: archons - older than 2500 M.y.; protons - between 2500 and 1600 M.y. and tectons - between 1600 and 800 M.y.

Many cratons, however, are overlain by younger, flat lying, little or undeformed sediments and volcanics (platform cover) so that, in many cases, it is not possible from direct observation to ascertain the nature of the underlying basement. The whole tectonic assemblage of cratonic blocks, mobile belts and cover rocks is often referred to as a Platform.

Furthermore, parts of a craton can be re-activated by a later thermal event and so become rejuvenated from archon to proton or tecton or from proton to tecton and this has consequences for its economic potential.

Close observation shows that all economic kimberlites in Southern Africa occur on the Kalahari Archon and most of them on the Kaapvaal nucleus within the Kalahari Archon. South African geologists go as far as stating that kimberlites occurring outside the boundaries of the Kalahari Archon do not contain any diamonds (Skinner, personal communication). Thus the kimberlites in Namibia, Bushmanland and the southern Cape Province are barren as they are located in the Namaqua-Natal province which is built up by protons and tectons.

Recent research in the USSR has shown that the basement of the Siberian Platform can be divided into several Archaean megablocks (archons) separated by Proterozoic mobile belts. Economic kimberlites (Mir, Aikhal, Udachnaya) occur only on the archons. It is also stated that the basement underneath the platform in the newly discovered kimberlite province 100km north of Arkhangel in Western Russia is Archaean.

In 1979 a primary source rock with a very high content of diamonds was found at Argyle in Western Australia which soon proved to be a very significant economic deposit.

The example of Argyle shows that economically significant, diamondiferous non-kimberlitic primary source rocks can occur "off-craton" (in the sense of Clifford), or off-archon (this paper), but located in an Early Proterozoic mobile belt which surrounds an Archaean craton.

The Argyle rocks, however, are not kimberlite but lamproite and worldwide examples show that other diamondiferous lamproites occur in Proterozoic terrains, i.e. protons.

Economic kimberlites occur in Archaean parts of the North China (Sino-Korean) Archon (Mengyin, Shandong and Fuxian, Liaoning). However, the basement to the Yangtze craton is generally of Proterozoic age, and the only primary source rock for diamond found so far is lamproite (Guizhou).

Diamondiferous, but so far non-economic, kimberlites (Aries, Skerring) occur on the Kimberley Archon, while an economic lamproite (Argyle) occurs in the Halls Creek Proton, close to the edge of the Kimberley Archon.

The Majhgawan pipe in central India, which was long thought to be a kimberlite has recently been classified as a lamproite; it lies right on the edge of the Aravalli Archon.

The alluvial diamonds in Kalimantan occur in areas underlain by highly deformed, medium grade metamorphic basement. Thus their source rocks are very distant or occur in a fragment of old cratonic terrain (Archon or Proton) which has not yet been found or recognised despite considerable exploration efforts by expatriate companies.

Worldwide observation also shows that the most and the largest diamond deposits occur on Archons which have the thickest platform cover and which have been uplifted the most. For example, within the Kalahari Archon, the Kaapvaal nucleus, which has a total thickness of Paleozoic and Mesozoic platform rocks in the order of at least 10,000m and an uplift of at least 3,000m, has the highest regional diamond content, while the Zimbabwe nucleus with a thinner platform cover (now mostly eroded) has the lowest.

Other cratons with high regional diamond potential are the Siberian Platform which has a substantial thickness of platform cover, while in Western Australia the Kimberley craton with its thick cover has proved richer than any other cratons in Australia which have lesser covers.

Perhaps there is a measurable relationship between regional diamond potential and the total thickness of the platform stratigraphic successions and the amount of subsequent uplift. To find this could be the challenge for the next few years.

It is concluded that if Clifford's rule is modified so that his "ancient cratons" represent truly Archaean terrain older than 2500 M.y., then it is still valid. Thus economic kimberlties occur "on-archon" and, in general, more towards the centre of an archon. (This modified Clifford's Rule was called the Clifford-Sinitsyn Rule at the Kimberlite Workshop held in Leningrad in March 1990). Economic lamproites, on the other hand, seem to occur along the periphery of an archon or in surrounding mobile belts preferably close to the edge of an archon. Prospecting methods should be tailored to the type of cratonic basement present to find the most likely primary source rocks.

However, because of the uncertainties in determining the exact petrological nature of the basement in platform areas and in rejuvenated terrain, there is still room for the "inspired" geologist or prospector who goes into the field to find a major diamond deposit in areas condemned by others.

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